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TECHNICAL SPECIFICATION

Ultra Wideband (UWB);
RF conformance testing of radar level gauging applications in stillpipes TLPR

Reference

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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The radar level gauges covered by the present document do not use the signal form of time domain UWB short pulses. Instead, they use the frequency domain based FMCW and/or SFCW waveforms. Thus the emission bandwidth generated by the FMCW and/or SFCW radars is strictly controlled by the equipment itself.

The specified requirements in the present document describe the worst case scenario (i.e. the possible highest emissions outgoing to the environment and incoming from interferer signal sources [10]) and is seen as a feasible test method to prove compliance of radar level gauging applications in stillpipes.

The background and related applications have been described in ETSI TR 102 750 [i.2] where the applications have been considered indoor like systems.

The purpose of revision of the present document is to update the previous version ETSI TS 102 692 (V1.1.1) [i.10] to cover the essential requirements of article 3.2 of the Directive 2014/53/EU [i.3].

1 Scope

The present document specifies the requirements for radar level gauging applications in stillpipes using UWB technology operating in the frequency range of 9 GHz to 10,6 GHz.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are necessary for the application of the present document.

[1] CISPR 16-1 (2003): "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1: Radio disturbance and immunity measuring apparatus".

[2] ANSI C63.5 (2006): "American National Standard for Electromagnetic Compatibility - Radiated Emission Measurements in Electromagnetic Interference (EMI) Control - Calibration of Antennas (9 kHz to 40 GHz)".

[3] Void.

[4] ISO 4266-1 (2002): "Petroleum and liquid petroleum products -- Measurement of level and temperature in storage tanks by automatic methods -- Part 1: Measurement of level in atmospheric tanks".

[5] API MPMS 3.1A and 3.1B: "Manual of Petroleum Measurement Standards, Chapter 3: Tank Gauging", Section 1A: "Standard Practice for the Manual Gauging of Petroleum and Petroleum Products", published on 1 of August 2005; Tank Gauging Section 1B: "Standard Practice for Level Measurement of Liquid Hydrocarbons in Stationary Tanks by Automatic Tank Gauging", published on 1 of June 2001.

[6] Void.

[7] ETSI TR 100 028 (all parts) (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[8] ETSI TR 102 273 (all parts) (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".

[9] Void.

[10] ETSI TS 103 361 (V1.1.1): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Receiver technical requirements, parameters and measurement procedures to fulfil the requirements of the Directive 2014/53/EU".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Recommendation ITU-R SM.1754: "Measurement techniques of ultra-wideband transmissions".

[i.2] ETSI TR 102 750: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radar level gauging applications in still pipes".

[i.3] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.4] Void.

[i.5] Void.

[i.6] Void.

[i.7] ETSI TS 103 052: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radiated measurement methods and general arrangements for test sites up to 100 GHz".

[i.8] Commission Decision 2007/131/EC of 21 February 2007 on allowing the use of the radio spectrum for equipment using ultra-wideband technology in a harmonised manner in the Community.

[i.9] Recommendation ITU-R P.526-10 (02/07): "Propagation by diffraction".

[i.10] ETSI TS 102 692 (V.1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); RF conformance testing of radar level gauging applications in still pipes".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

dedicated waveguide antenna: device/structure to excite a certain waveguide mode that propagates inside a waveguide only

duty cycle: ratio of the total on time of the transmitter to the total time

emissions: signals that leaked or are scattered into the air within the frequency range (that includes harmonics) which depend on equipment's frequency band of operation

equivalent isotropically radiated power (e.i.r.p.): total power transmitted, assuming an isotropic radiator

EUT: radar level gauge with a dedicated waveguide antenna on a dedicated stillpipe

external floating roof: roof made of metallic material such as aluminium

NOTE: It moves along with the filling liquid below the roof inside the tank.

Frequency Modulated Continuous Wave (FMCW) radar: radar where the transmitter power is fairly constant but possibly zero during periods giving a big duty cycle (such as 0,1 to 1)

NOTE: The frequency is modulated in some way giving a very wideband spectrum with a power versus time variation which is clearly not pulsed.

operating frequency (operating centre frequency): nominal frequency at which equipment is operated

pulsed radar: radar where the transmitter signal has a microwave power consisting of short RF pulses

radiated measurements: measurements that involve the absolute measurement of a radiated field

radiation: signals emitted intentionally inside a tank for level measurements

Stepped Frequency Continuous Wave (SFCW) radar: radar where the transmitter sequentially generates a number of frequencies with a step size

NOTE: At each moment of transmission, a monochromatic wave is emitted. It is distinguished from FMCW that has the instantaneous frequency band rather than a single frequency wave. The SFCW radar bandwidth is synthesized by signal processing to achieve required resolution bandwidth.

stillpipe: still-well, stilling-well, guide pole: Vertical, perforated metallic pipe built into a tank to reduce measurement errors arising from liquid turbulence, surface flow or agitation of the liquid

NOTE: Any equipment made of a perforated steel pipe with diameters varying from a few centimetres up to several decimetres. The perforations enable the liquid to freely flow into and out of the stillpipe at all levels in a tank. Stillpipes are the preferred installation point of a Tank Level Probing Radar inserted inside a floating or open roof tanks.

stillpipe TLPR: tank level probing radar coupled onto a stillpipe as one part installed through an external floating roof in a tank

user manual: end user documentation to be included with the device

3.2 Symbols

For the purposes of the present document, the following symbols apply:

a	edge length of corner reflector (compare figure M.1)
$a^{dB}_{coupler(1-2)}$	coupling loss of the directional coupler between ports 1 and 2 in dB
$a^{dB}_{coupler(1-3)}$	coupling loss of the directional coupler between ports 1 and 3 in dB
$a^{dB}_{cable\_A}$	cable loss of coaxial RF-cable A in dB
$a^{dB}_{cable\_B}$	cable loss of coaxial RF-cable B in dB
$a^{dB}_{attn\_A}$	attenuation of the coaxial attenuator A in dB
$a^{dB}_{attn\_B}$	attenuation of the coaxial attenuator B in dB
c	velocity of light in a vacuum
cl1	cable loss 1
cl2	cable loss 2
dB	deciBel
dBi	gain in deciBel relative to an isotropic antenna
dBm	deciBel reference to 1 mW
D	duty cycle
E	electrical field strength
E_R	relative dielectric constant of earth materials
E_{rms}	average electrical field strength measured as root mean square
f_c	frequency at which the emission is the peak power at maximum
G	efficient antenna gain of radiating structure
G_{LNA}	gain of the measurement LNA

G_A	gain of the measurement antenna
$G(f)$	antenna gain over frequency
f_H	highest frequency of the frequency band of operation
f_L	lowest frequency of the frequency band of operation
k	boltzmann constant
P	power
$P_{e.i.r.p.}$	power spectral density
P_m	measured spectral power
$P_{wall,\ e.i.r.p.}$	unwanted power spectral density
$P_{r\_interferer}$ $\left(P_{r\_interferer}^{\mathrm{dBm}}\right)$	received interferer power at the location of the TLPR in Watt (in dBm)
$P_{t\_interferer}$ $\left(P_{t\_interferer}^{dBm}\right)$	transmitted interferer power (generated by the signal generator) in Watt (in dBm)
P_{r_real} $\left(P_{r\_real}^{dBm}\right)$	received echo power in the real measurement scenario in Watt (in dBm)
P_t (P_t^{dBm})	maximum value of peak power of the TLPR in Watt (in dBm) in the real measurement scenario
$P_{r\_equivalent}$ $\left(P_{r\_\mathrm{equivalent}}^{dBm}\right)$	received echo power in the equivalent measurement scenario in Watt (in dBm)
P_s	output power of the signal generator measured by power meter
R	distance
rms	root mean square
r	reflection coefficient of the considered surface in the real measurement scenario
R_{max}	maximum measurement distance which the individual sensor is still able to reliably measure under the influence of an interferer
R	distance between stillpipe TLPR and test antenna
t	time
Δd	measurement value variation over time during a distance measurement
λ	wavelength in general or wavelength of the TLPR transmit signal at centre frequency
ε_r	relative permittivity of the surface material in the real measurement scenario

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC/DC	Alternating Current/Direct Current
API	American Petroleum Institute
BFWA	Broadband Fixed Wireless Access
BW	BandWidth
CE	European Conformity
DC	Duty Cycle
e.i.r.p.	equivalent isotropically radiated power
EM	ElectroMagnetic
EUT	Equipment Under Test
FMCW	Frequency Modulated Continuous Wave
IT	Information Technology
LNA	Low Noise Amplifier
NLOS	Non Line-Of -Sight
OATS	Open Area Test Site
OE	Other Emissions
PC	Personal Computer
RF	Radio Frequency
RMS	Remote Management System
RX	Receiver
SFCW	Stepped Frequency Continuous Wave
SMA	Sub Miniature type A (connector)

TLPR	Tank Level Probing Radar
TX	Transmitter
UWB	Ultra WideBand
VSWR	Voltage Standing Wave Ratio

4 General testing requirements

4.1 Environmental conditions

Tests defined in the present document shall be carried out at representative points within the boundary limits of the declared operational environmental profile.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the declared operational environmental profile) to give confidence of compliance for the affected technical requirements. The test conditions are defined in clause 5.

4.2 Presentation of equipment for testing purposes

The manufacturer shall submit one or more samples of the equipment as appropriate for testing.

Additionally, technical documentation and operating manuals, sufficient to allow testing to be performed, shall be supplied.

The performance of the equipment submitted for testing shall be representative of the performance of the corresponding production model. In order to avoid any ambiguity in that assessment, the present document contains instructions for the presentation of equipment for testing purposes (see clause 4), conditions of testing (see clauses 5 and 6), interpretation of results (see clause 7), the measurement methods and limits for transmitters (see clause 8), receiver conformance requirements (see clause 9) and conformance test suite for receiver parameters (see clause 10).

The manufacturer shall offer equipment complete with any auxiliary equipment needed for testing.

4.3 Choice of model for testing

4.3.0 General

One or more samples of the EUT, as described in annex C, shall be tested for both transmitter and receiver parameters, respectively in accordance with clauses 8 and 10.

4.3.1 Declarations by the manufacturer

The manufacturer shall submit the necessary information regarding the equipment with respect to all technical requirements set by the present document.

4.3.2 Marking and equipment identification

The equipment shall be marked in a visible place. This marking shall be legible and durable.

The marking shall include as a minimum:

- The name of the manufacturer or his trademark.
- The type designation. This is the manufacturer's numeric or alphanumeric code or name that is specific to particular equipment.

4.4 Mechanical and electrical design

4.4.1 General

The equipment submitted by the manufacturer shall be designed, constructed and manufactured in accordance with good engineering practice and with the aim of minimizing harmful interference to other equipment and services and maximizing the handling capability of interferer signals from other equipment to the receiver.

4.5 Interpretation of the measurement results

4.5.0 General

The interpretation of the results recorded on the appropriate test report for the measurements described in the present document shall be as follows:

- the measured value relating to the corresponding limit together with the appropriate mitigation factors as described in clause 8.4 shall be used to decide whether an equipment meets the requirements of the present document;
- the measurement uncertainty value for the measurement of each parameter shall be included in the test report.

The measurement uncertainty is explained in clause 7. Additionally, the interpretation of the measured results depending on the measurement uncertainty is described in clauses 4.5.1 and 4.5.2.

For radiated UWB emissions measurements below 9 GHz and above 10,6 GHz it may not be possible to reduce measurement uncertainty to the levels specified in clause 7, table 2 (due to the very low signal level limits and the consequent requirement for high levels of amplification across wide bandwidths). In these cases alone it is acceptable to employ the alternative interpretation procedure specified in clause 4.5.2.

4.5.1 Measurement uncertainty is equal to or less than maximum acceptable uncertainty

The interpretation of the results when comparing measurement values with specification limits shall be as follows:

a) When the measured value does not exceed the limit value the equipment under test meets the requirements of the present document.

b) When the measured value exceeds the limit value the equipment under test does not meet the requirements of the present document.

c) The measurement uncertainty calculated by the test technician carrying out the measurement shall be recorded in the test report.

d) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement undertaken. The method used shall be recorded in the test report.

4.5.2 Measurement uncertainty is greater than maximum acceptable uncertainty

The interpretation of the results when comparing measurement values with specification limits should be as follows:

a) When the measured value plus the difference between the measurement uncertainty calculated by the test technician and the maximum acceptable measurement uncertainty does not exceed the limit value, the equipment under test meets the requirements of the present document.

b) When the measured value plus the difference between the measurement uncertainty calculated by the test technician and the maximum acceptable measurement uncertainty exceeds the limit value the equipment under test does not meet the requirements of the present document.

c) The measurement uncertainty calculated by the test technician carrying out the measurement shall be recorded in the test report.

d) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement undertaken. The method used shall be recorded in the test report.

5 Test conditions, power sources and ambient temperatures

5.1 Normal conditions

All testing shall be made under normal test conditions.

The test conditions and procedures shall be as specified in clause 5.2.

5.2 External test power source

5.2.0 General

During tests, the power source of the equipment shall be an external test power source, capable of producing normal voltages. The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible.

The test voltage shall be measured at the point of connection of the power cable to the equipment.

During tests, the external test power source voltages shall be within a tolerance of ±1 % relative to the voltage at the beginning of each test. The level of this tolerance can be critical for certain measurements. Using a smaller tolerance provides a reduced uncertainty level for these measurements.

The power source used during the test shall be stated in the test report.

5.2.1 Internal test power source

For radiated measurements on portable equipment with integral antenna, fully charged internal batteries should be used. The batteries used should be as supplied or recommended by the manufacturer. If internal batteries are used, at the end of each test the voltage shall be within a tolerance of less than ±5 % relative to the voltage at the beginning of each test.

5.3 Normal test conditions

5.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

- temperature + 15 °C to + 35 °C;
- relative humidity 20 % to 75 %.

When it is impractical to carry out tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

5.3.2 Normal test power source

5.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages, for which the equipment was designed.

5.3.2.2 Other power sources

For operation from other power sources (primary or secondary), the normal test voltage shall be that declared by the equipment manufacturer and agreed by the test laboratory. Such values shall be stated in the test report.

6 General conditions

6.1 Radiated measurement arrangements of transmitter

6.1.0 General requirements

For guidance on radiation test sites and general arrangements for radiated measurements of transmitter, see annexes A and C.

Informative descriptions of radiated measurement arrangements for UWB devices can be found in Recommendation ITU-R SM.1754 [i.1].

All reasonable efforts should be made to clearly demonstrate that emissions from the UWB transmitter do not exceed the specified levels, with the transmitter in the far field. To the extent practicable, the equipment under test should be measured at the distance specified in annex A and with the specified measurement bandwidths. However, in order to obtain an adequate signal-to-noise ratio in the measurement system, radiated measurements may have to be made at distances less than those specified in annex A and/or with reduced measurement bandwidths. The revised measurement configuration should be stated in the test report, together with an explanation of why the signal levels involved necessitated measurement at the distance employed or with the measurement bandwidth used in order to be accurately detected by the measurement equipment, and calculations demonstrating compliance.

Where it is not practical to further reduce the measurement bandwidth (either because of limitations of commonly-available test equipment or difficulties in converting readings taken using one measurement bandwidth to those used by the respective limit table), and the required measurement distance would be so short that the device would not clearly be within the far field, the test report shall state this fact, the measurement distance and bandwidth used, the near field/far field distance for the measurement setup (see clause clause A.2.4), the measured device emissions, the achievable measurement noise floor and the frequency range(s) involved.

6.1.1 Modes of operation of the transmitter

For the purpose of the measurements according to the present document, there shall be a facility to operate the transmitter in a continuous state, whereby the radar signal is transmitted repeatedly and any gating techniques switched off.

6.1.2 Measuring receiver

The term measuring receiver refers to a spectrum analyser. The reference bandwidth of the measuring receiver as defined in CISPR 16-1 [1] shall be as given in table 1.

Table 1: Reference bandwidth of measuring receiver

Frequency being measured: f	Spectrum analyser bandwidth
30 MHz ≤ f < 1 000 MHz	100 kHz
1 000 MHz ≤ f	1 MHz

6.2 Receiver measurement arrangements

The receiver measurement parameters that shall be tested to meet the essential requirements of article 3.2 of the Directive 2014/53/EU [i.3] are defined in clause 6.3 of ETSI TS 103 361 [10]. The receiver test conformance requirements and test arrangement are defined in clauses 9 and 10 respectively.

7 Interpretation of results

7.1 Measurement uncertainty

Interpretation of the results recorded in the test report for the measurements described in the present document shall be as follows:

- the measured value related to the corresponding limit shall be used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter shall be separately included in the test report;
- the value of the measurement uncertainty shall be wherever possible equal for each measurement, equal to or lower than the figures in table 2, and the interpretation procedure specified in clause 4.5.1 shall be used.

Table 2: Measurement uncertainty [i.7]

Parameter	Maximum expanded measurement Uncertainty
Radio frequency	$\pm 1 \times 10^{-7}$
Radiated RF power (up to 40 GHz)	±6 dB
Radiated RF power (above 40 GHz up to 66 GHz)	±8 dB
Radiated RF power (above 66 GHz up to 100 GHz)	±10 dB (see note 1)
Radiated RF power (above 100 GHz)	See note 2
Conducted Measurements (up to 18 GHz)	±1,5 dB
Conducted Measurements (up to 40 GHz)	±2,5 dB
Conducted Measurements (up to 100 GHz)	±4 dB
Conducted measurements (above 100 GHz)	See note 2
Temperature	±1 °C
Humidity	±5 %
DC and low frequency voltages	±3 %
NOTE 1: Achieved sensitivity and measurement uncertainty are a direct result of the chosen test suites. The values mentioned together with the concerns should therefore be considered illustrational rather than absolute for radiated measurements above 66 GHz, given the absence of some relevant information. For radiated emissions above 66 GHz the given measurement uncertainties are based on the assumption of the deployment of a cable based measurement set-up. NOTE 2: For measurements above 100 GHz, the expanded measurement uncertainty shall also be recorded in the test report and a detailed calculation shall be added. A future revision of the present document may include a value for frequencies above 100 GHz for expanded measurement uncertainty that is still under development.	

For the test methods, according to the present document the uncertainty figures shall be calculated according to the methods described in ETSI TR 100 028 [7] and shall correspond to an expansion factor (coverage factor) k = 1,96 or k = 2 (which provide confidence levels of respectively 95 % and 95,45 % in cases where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Table 2 is based on such expansion factors.

The particular expansion factor used for the evaluation of the measurement uncertainty shall be stated.

NOTE: Information on uncertainty contributions, and verification procedures are detailed in ETSI TR 102 273 [8].

8 Methods of measurement and limits for transmitter parameters

8.1 General

The radar level gauging applications covered by the present document use a stillpipe (a hollow waveguide) to convey the radar signal to the liquid surface in the pipe and back again (see annex C). The system is functionally shielded by the stillpipe but due to the perforations necessary to make the liquid level inside the pipe exactly the same as that in the tank, a small amount of RF leakage may unintentionally occur. The measurements described below aim to measure the worst case of that RF leakage.

8.2 Permitted range of operating frequencies

8.2.1 Definition

The permitted range of operating frequencies is the frequency range over which the equipment is intended to operate.

8.2.2 Method of measurement

The minimum and maximum frequencies of the permitted range of frequencies of clause 8.2.3 shall be measured using the radiated method shown in figure 1.

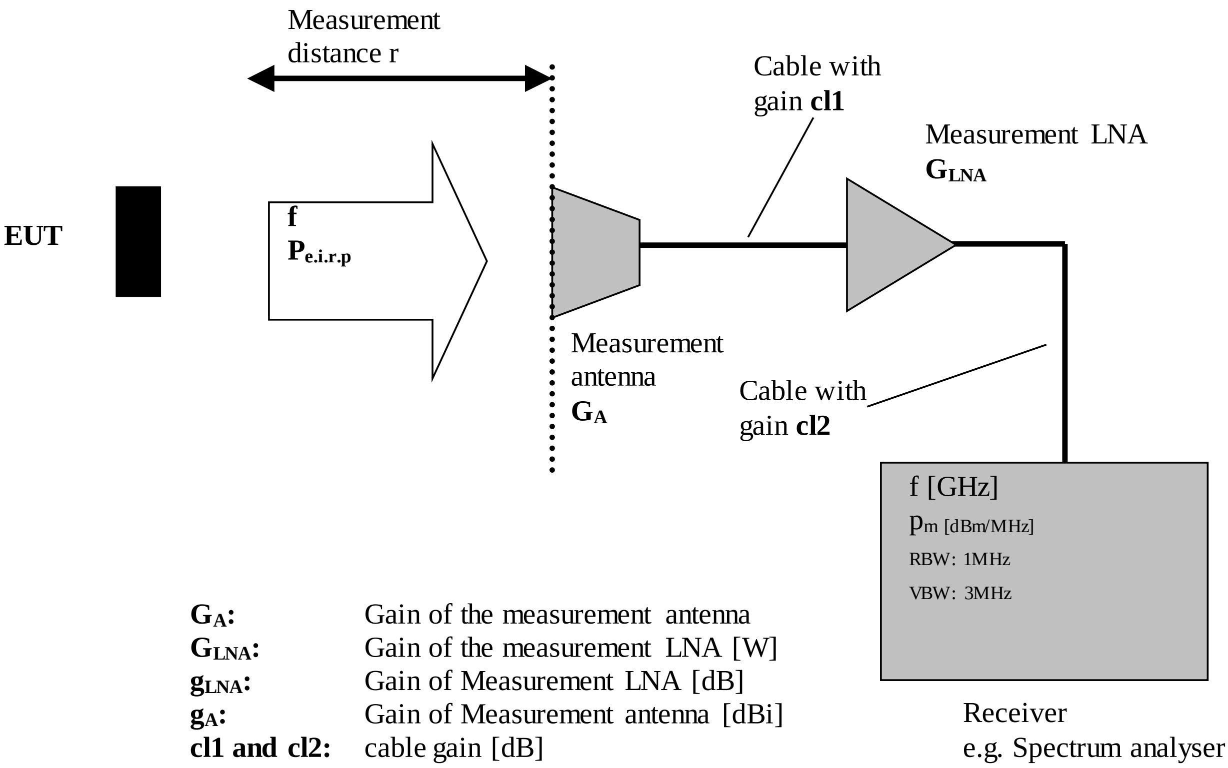


Figure 1: Test set-up for measuring the operating frequency range

Conversion:

$$g_{LNA} = 20\log(G_{LNA})$$

$$g_A = 10\log(G_A)$$

$$cl_x = 10^{\left(\frac{Cl_x}{20}\right)}$$

Equation (Values [dB]):

$$p_{e.i.r.p} = p_m - g_A - cl1 - cl2 - g_{LNA} + 20 \cdot \log\left(\frac{4\pi r}{\lambda}\right) \text{ [dBm/MHz]} \qquad (1)$$

The values of the cable gain Cl1 and Cl2 are smaller than one. Consequently the logarithmic values cl1 and cl2 are negative!

A test site selected from annex A (i.e. indoor test site or open area test site), which fulfils the requirements of the specified frequency range and undisturbed lowest specified emission levels of this measurement shall be used.

The measurement procedure shall be as follows:

- place the spectrum analyser in video averaging mode and max hold mode with a minimum of 50 sweeps selected and activate the transmitter with normal radar signal applied;
- find lowest frequency below the operating bandwidth at which spectral power density decreases to the level given in clause 8.2.3. This frequency shall be recorded;
- find the highest frequency at which the spectral power density decreases to the level given in clause 8.2.3. This frequency shall be recorded;

- the difference between the lowest frequency and highest frequency measured is the frequency range which shall be recorded.

This measurement shall be repeated for each operating bandwidth as declared by the manufacturer.

The results obtained shall be compared to the limit in clause 8.2.3.

8.2.3 Limits Frequency range

The permitted range of operating frequencies for radiation is given in table 3. Outside the permitted range of operating frequencies the emissions shall be reduced by no less than 10 dB.

Table 3: Frequency band of operation

Frequency band of operation
9 GHz to 10,6 GHz

8.3 Emissions

8.3.1 Definition

The total of emissions is the sum of wanted UWB emissions in the permitted frequency range of operation and outside of the permitted frequency range of operation as well as the other emissions. Other emissions can occur inside as well as outside of the frequency range of operation.

8.3.2 UWB emissions

8.3.2.0 General

UWB emissions are any UWB leakage signals from the stillpipe perforations. The UWB emission limits are to be in accordance with the Commission Decision 2007/131/EC [i.8] on UWB devices. The radar level gauges intended for the use in above mentioned frequency range do not use the time domain UWB short pulses. Instead the radar level gauges covered by the present document use the frequency domain FMCW and/or SFCW waveforms. Thus the frequency band generated by the FMCW and/or SFCW radars is strictly controlled.

8.3.2.1 Method of measurement

Radiated measurements shall be performed according to the method using the measurement setup and test pipe as described in annexes A and C.

Measurements shall be carried out over the frequency ranges as shown in clause 8.3.2.2, tables 5a, 5b and 6.

When measuring maximum mean power spectral density from the equipment under test, the spectrum analyser or equivalent shall be configured as follows unless otherwise stated:

- Resolution bandwidth: 1 MHz.

NOTE 1: In order to obtain an adequate signal-to-noise ratio in the measurement system, radiated measurements may have to be made using narrower resolution bandwidths where it is practical. In these cases, the revised measurement configuration should be stated in the test report, together with calculations which permit the measurements taken to be compared with the appropriate limits and an explanation of why the signal levels involved necessitated measurement using the resolution bandwidth employed in order to be accurately determined by the measurement equipment.

- Video bandwidth: Not less than the resolution bandwidth.
- Detector mode: RMS.

NOTE 2: RMS average measurements can be accomplished directly using a spectrum analyser which incorporates an RMS detector. Alternatively, a true RMS level can be measured using a spectrum analyser that does not incorporate an RMS detector (see Recommendation ITU-R SM.1754 [i.1] for details).

- Average time (per point on spectrum analyser scan): 1 ms or less.
- Frequency Span: Equal to or less than the number of displayed samples multiplied by the resolution bandwidth. The measurement results shall be determined and recorded over the frequency ranges as shown in clause 8.3.3.2, tables 5a, 5b and 6.

The measurements shall be repeated at the frequency band edges at 9 GHz and 10,6 GHz. The measurements at the frequency band edges shall be performed at the frequency offsets as shown in table 4.

Table 4: Frequency offsets for band edge measurements

Band edge frequency (GHz)	Frequency with frequency offset applied
9	9 GHz - 20 MHz
10,6	10,6 GHz + 20 MHz

This frequency offset that is shown in table 4 is necessary since measurements at the exact frequency edges with a spectrum analyser may integrate energy from both sides of the respective band edge frequency. This is caused by the filter bandwidth of the test equipment. When measuring maximum peak power in the wanted frequency range from the device under test, the spectrum analyser used should be configured as follows:

- Frequency: The measurement shall be centred on the frequency at which the maximum mean power spectral density occurs.
- Resolution bandwidth: Equal or greater than 10 MHz but not greater than 50 MHz.

NOTE 3: For peak power measurements, the best signal to noise ratio is usually obtained with the widest available resolution bandwidth.

- Video bandwidth: Not less than the resolution bandwidth.
- Detector mode: Peak.
- Display mode: Maximum Hold.
- Measurements shall be continued until the displayed trace no longer changes.

NOTE 4: To the extent practicable, the device under test is measured using a spectrum analyser configured using the settings described above. However, in order to obtain an adequate signal-to-noise ratio in the measurement system, radiated measurements may have to be made using narrower resolution bandwidths. In these cases, the revised measurement configuration should be stated in the test report, together with calculations which permit the measurements taken to be compared with the appropriate limits and an explanation of why the signal levels involved necessitated measurement using the resolution bandwidth employed in order to be accurately determined by the measurement equipment.

8.3.2.2 Limits

The maximum mean equivalent isotropically radiated power spectral density and the maximum peak e.i.r.p. measured shall not exceed the limit given in tables 5a, 5b and 6.

Table 5a: Maximum mean e.i.r.p. spectral density limit

Frequency range (GHz)	Maximum mean e.i.r.p. spectral density (dBm/MHz)
9 to 10,6	-65

Table 5b: Maximum peak e.i.r.p. limit

Frequency range (GHz)	Maximum peak e.i.r.p (dBm)
9 to 10,6	-25

The maximum mean equivalent isotropically radiated power spectral density measured outside the permitted frequency band of operation shall not exceed the limits given in table 6.

Table 6: Maximum mean e.i.r.p. density limit outside the band

Frequency range (GHz)	Maximum mean e.i.r.p. density (dBm/MHz)
6 to < 9	-75
> 10,6 to 22	-85

8.3.3 Other Emissions (OE)

8.3.3.1 Definition

UWB transmitters emit very low power radio signals, comparable with the power of spurious emissions from digital and analogue circuitry. If it can be clearly demonstrated that an emission from an UWB device is not an UWB emission (e.g. by disabling the device's UWB transmitter) or it can clearly be demonstrated that it is impossible to differentiate between other emissions and the UWB transmitter emissions, that emission or aggregated emissions shall be considered against the other emission limits.

Proper pre-select filtering can be incorporated to protect the measurement system low-noise pre-amplifier from overload. In addition, all ambient signals can be detected prior to the activation of the UWB transmitter in order to remove the ambient signal contributions present in the measured spectra. This will require post-processing of the measurement data utilizing a computer and data analysis software when necessary.

8.3.3.2 Method of measurement

The transmitter shall be switched on, with normal radar signal and the spectrum analyzer shall be tuned to the frequency of the signal being measured. The test antenna shall be oriented for vertical polarization and shall be raised or lowered through the specified height range until a maximum signal level is detected on the test receiver.

The transmitter shall be rotated horizontally through 360° until the highest maximum signal is received.

NOTE: This maximum may be a lower value than the value obtainable at heights outside the specified limits.

The transmitter shall be replaced by a substitution antenna and the test antenna raised or lowered as necessary to ensure that the maximum signal is still received. The input signal to the substitution antenna shall be adjusted in level until an equal or a known related level to that detected from the transmitter is obtained in the test receiver.

The carrier power is equal to the power supplied to the substitution antenna, increased by the known relationship if necessary.

The measurement shall be repeated for any alternative antenna supplied by the provider.

A check shall be made in the horizontal plane of polarization to ensure that the value obtained above is the maximum. If larger values are obtained, this fact shall be recorded in the test report.

Test shall be performed under normal test conditions.

One test site selected from annex A shall be used.

The applicable spectrum shall be searched for emissions that exceed the limit values or that come to within 6 dB below the limit values given in clause 8.3.3.3. Each occurrence shall be recorded.

Measurements shall be carried out over the frequency range from 30 MHz to 22 GHz.

The measurements shall be performed only under the following conditions:

- The measurements are made with a spectrum analyser, the following settings shall be used for narrowband emissions:
  - resolution BW: 100 kHz below 1 GHz; 1 MHz above 1 GHz;
  - video BW: 300 kHz below 1 GHz; 3 MHz above 1 GHz;
  - detector mode: positive peak;
  - averaging: off;
  - span: 100 MHz;
  - amplitude: adjust for middle of the instrument's range;
  - sweep time: 1 s.

For measuring emissions that exceed the level of 6 dB below the applicable limit, the resolution bandwidth shall be switched to 30 kHz and the span shall be adjusted accordingly. If the level does not change by more than 2 dB, it is a narrowband emission; the observed value shall be recorded. If the level changes by more than 2 dB, the emission is a wideband emission and its level shall be measured and recorded.

The results obtained shall be compared to the limits in clause 8.3.3.3 in order to prove compliance with the requirements.

8.3.3.3 Limits

Other narrowband emissions shall not exceed the values in table 7 in the indicated bands.

Table 7: Other narrowband emission limits

Frequency range	Limit
30 MHz to 1 GHz	-57 dBm (e.r.p.)
above 1 GHz to 22 GHz	-47 dBm (e.i.r.p.)

The above limit values apply to narrowband emissions, e.g. as caused by local oscillator leakage. The measurement bandwidth for such emissions may be as small as necessary to get a reliable measurement result.

Other wideband emissions shall not exceed the values given in table 8.

Table 8: Other wideband emission limits

Frequency range	Limit
30 MHz to 1 GHz	-47 dBm/MHz (e.r.p.)
above 1 GHz to 22 GHz	-37 dBm/MHz (e.i.r.p.)

8.4 Mitigation techniques

8.4.0 General

The stillpipe applications covered by the present document do not use the time domain UWB short pulses. Instead the frequency domain FMCW and/or SFCW is used. Thus the frequency band generated by the FMCW and/or SFCW radars are strictly controlled. The mitigation techniques described here are intended to be applied to the emission limits as described in clause 8.3.2 (except for clause 8.4.1 for emissions below 3 GHz). The measured values recorded shall be reduced by the values provided by the mitigation techniques applied according to equation (2):

Final value (dBm/MHz) = Measured value (dBm/MHz) - total mitigation factor (dB) (2)

The mitigations can be classified into following categories.

8.4.1 Shielding effects

8.4.1.1 Applicability

This requirement shall apply to all EUT.

8.4.1.2 Description

A radar level gauge with its dedicated stillpipe is a completely shielded system with a very high screening attenuation. The excited EM field has the unique property that confines the energy propagating inside the cylindrical pipe along axis. In this way, the unintentional emission is limited by this special installation.

An external floating roof is made of metallic material such as aluminium. The roof acts as a shielding to prevent the leaked energy from the stillpipe. Furthermore, the tank wall screens the leaked signal from the stillpipe perforations. The tank shell by knife-edge diffraction makes the emission in the direction around the horizontal line quite small according to the calculations from Recommendation ITU-R P.526-10 [i.9]. The perforations always at least begin at 0,8 m below the top of the tank shell which is a natural upper limit for the liquid movements. No openings above the floating roof exist in practice. The reduction factor of the tank wall shielding applicable for stillpipe applications is 30 dB according to Recommendation ITU-R P.526-10 [i.9]. This mitigation applies to all emissions above 3 GHz.

8.4.1.3 Limits

Not applicable.

8.4.1.4 Conformance

The product manual shall have the necessary information to enable a correct installation of the TLPR equipment according to annex B.

8.4.2 Frequency domain mitigation

8.4.2.1 Applicability

This requirement shall apply to all EUT which implemented this mitigation technique. The usage shall be declared by the manufacturer.

8.4.2.2 Description

For SFCW/FMCW modulation, the instantaneous bandwidth of the radar signal is close to zero. The mitigation naturally offered by SFCW/FMCW radar is the zero instantaneous bandwidth. The swept band over longer time is not able to generate simultaneous interferences to the victim receivers. For instance, the stepped frequency radar sweeps ca. 1 000 steps, within a period of approximately 100 ms. At each step the radar transmits a different frequency with dwell time of 100 µs within 1 MHz. For a 10 MHz victim receiver bandwidth, the equivalent duty cycle is 10×100 µs / 100 ms = 1 %. This is equivalent to a mitigation factor of 20 dB.

8.4.2.3 Limits

Limits for modulation parameters are declared by manufacturer in clause E.5.1.

8.4.2.4 Conformance

Frequency domain mitigation of the TLPR shall be declared by the manufacturer. No test needs to be conducted.

8.4.3 Equivalent mitigation techniques

8.4.3.1 Applicability

This requirement shall apply to all EUT which implemented this mitigation technique. The usage shall be declared by the manufacturer.

8.4.3.2 Description

Other mitigation techniques and mitigation factors can be taken into account for the calculation of the maximum allowed TX power of a stillpipe TLPR device, as long as reached mitigation factors are equivalent or higher than the mitigation factors reached using the presented techniques in the present document. Examples for additional mitigation factors could be the deployment of the radio device in a restricted indoor area with higher wall attenuation. The additional mitigation factors need to be weighed against the specific services to be protected.

The manufacturer shall provide sufficient information for determining compliance with the stillpipe TLPR emission limits in clauses 8.3.3 when using equivalent mitigation techniques.

NOTE: Regulations in the EC decision 2007/131/EC [i.8] and its amendment allow for other equivalent mitigation techniques to be used across all frequency bands, where these offer at least equivalent protection to that provided by the limits in the decision.

8.4.3.3 Conformance

The equivalent mitigation techniques of the stillpipe TLPR shall be declared by the manufacturer. No test needs to be conducted.

8.4.4 Thermal Radiation

All external floating roof tanks are huge in size (Φ=30 m to 80 m and ≈ 20 m high), which implies a low density of stillpipe TLPRs installed in stillpipes, and are always located in industrial hazardous areas with very restricted admittance. Only a very low percentage of such installed areas exist in a country. 100 floating roof tanks in a single area are considered as a big tank farm.

At high elevation angles towards a possible satellite receiver front end or an aeronautical onboard aircraft receiver the edge diffraction will not contribute.

According to the Planck's law, the thermal radiation from a "black" surface is calculated by $4\pi kTB/\lambda^2$ and equals at 10 GHz to about -73 dBm/MHz × m^2. An outdoor tank with diameter of 40 meters has got a thermal radiation of approximately -42 dBm/MHz.

Thus the average of the emitted power from the tank surface will be well below the thermal noise as seen from the sky.

9 Receiver Conformance Requirements

9.1 Receiver requirements

Detailed description for related UWB receiver requirements are described in ETSI TS 103 361 [10].

9.2 Receiver spurious emissions

Receiver spurious emissions are measured as part of the emissions resulting from the operation of clause 8.3.3.

9.3 Receiver interference signal handling

9.3.1 Applicability

This requirement shall apply to all EUT.

9.3.2 Description

Interferer signal handling is defined as the capability of the device to properly operate in coexistence with interferers in a defined frequency range without exceeding a given degradation due to the presence of an interfering input signal at the receiver of the EUT. The interferer signals that shall be used in the conformance test to meet the essential requirements of article 3.2 of the Directive 2014/53/EU [i.3] are defined in ETSI TS 103 361 [10], in particular in clause 7.7 and tables 10 and 11.

The quality of the EUT ensures a proper operation in an environment where several users share an assigned frequency band and demonstrates the efficient use of radio spectrum by way of an increased resilience against harmful interference in the operating bandwidth of the EUT.

The intended use of stillpipe radar equipment is to measure the distance to a liquid or solid material in a tank, in order to determine its filling level. The performance criterion for interferer signal handling is the distance value variation Δd which is observed during the measurement against a fixed radar target over a defined period of time under the influence of an interfering signal.

The measurement target in a real scenario is a smooth flat surface consisting of a material with relative permittivity ε_r in a defined distance to the radar antenna, whereby a specular reflection at the surface can be expected.

The manufacturer states the combination of the minimum relative permittivity ε_r and the maximum measurement distance R_{max} which individual stillpipe radar gauges are able to reliably measure the distance under the influence of an interferer using a specific antenna with gain G.

The values for ε_r, R_{max} and G shall be noted in the "application form for testing". The template of this form is provided in annex E.

The measurement value variation Δd observed under interference conditions over at least 120 seconds or 40 times the step response time of the EUT, whichever is longer, shall not exceed a defined limit.

9.3.3 Limits

The maximum allowed measured distance value variation Δd under interference conditions shall not exceed ±50 mm.

The performance criterion and the result of level of performance shall be stated in the user manual and in the "application form for testing".

The following text shall be used in the user manual:

"For the receiver test that covers the influence of an interferer signal to the device, the performance criterion has at least the following level of performance according to ETSI TS 103 361 [10].

- Performance criterion: measurement value variation Δd over time during a distance measurement.
- Level of performance: Δd ≤ ±50 mm".

9.3.4 Conformance

The conformance test suite for interferer signal handling shall be as defined in clause 10.1.4.1 for the radiated test under the equivalent scenario.

The conformance test suite for interferer signal handling shall be as defined in clause 10.1.4.2 for the conducted test under the equivalent scenario.

The conformance test suite for interferer signal handling shall be as defined in clause 10.1.5.1 for the conducted test under the alternative scenario.

Thus there are altogether three possible test setups, which can be equivalently used in order to demonstrate the conformity of the EUT. The manufacturer shall declare which test setup is used. This shall be stated in the test report.

Conformance shall be established under the normal test conditions as defined in clause 5.3.

The interpretation of the results for the measurement uncertainty shall be as given in clause 4.5.

10. Conformance test suite for receiver parameters

10.1 Interferer signal handling

10.1.1 Description

Interferer signal handling is defined as the capability of the device to properly operate as intended use in coexistence with interferers in a defined frequency range without exceeding a given degradation due to the presence of an interfering input signal at the receiver of the stillpipe TLPR.

The interferer test frequency range, interferers and interferer power levels, test scenario, performance criterion and level of performance shall be recorded in the test report.

10.1.2 Interferer frequencies and power levels

The interferer frequencies and power levels which have to be applied to the stillpipe TLPR under test, shall be determined using the procedures described in ETSI TS 103 361 [10] where the mitigation factors and X-band frequencies shall refer to the clause 7.7, table 10 and 11. The attenuation factor on external interference signal is given as NLOS of 40 dB which is true for stillpipe TLPR\. The reason is that a radar level gauge with its dedicated antenna and stillpipe is a completely shielded system with a very high screening attenuation. The EM field excited by the dedicated antenna has the unique property that it confines the energy propagating inside the cylindrical pipe along axis. In this way, the unintentional emission is significantly limited by this special installation. An external floating roof is made of metallic material such as aluminium. The roof acts as a shielding to prevent the leaked energy from the stillpipe. More information about stillpipe TLPR applications in tanks with external floating roof is elaborated in ETSI TR 102 750 [i.2].

Furthermore, the tank wall screens the leaked signal from the stillpipe perforations. The tank shell by knife-edge diffraction makes the emission in the direction around the horizontal line quite small according to the calculations from Recommendation ITU-R P.526-10 [i.9]. The perforations always at least begin at 0,8 m below the top of the tank shell which is a natural upper limit for the liquid movements. No openings above the floating roof could exist in practice (see figure 4). Therefore attenuation of interferer signal by the tank wall shielding and stillpipe is 40 dB which is the same as defined in ETSI TS 103 361 [10], clause 7.7. This mitigation applies to all emissions above 3 GHz.

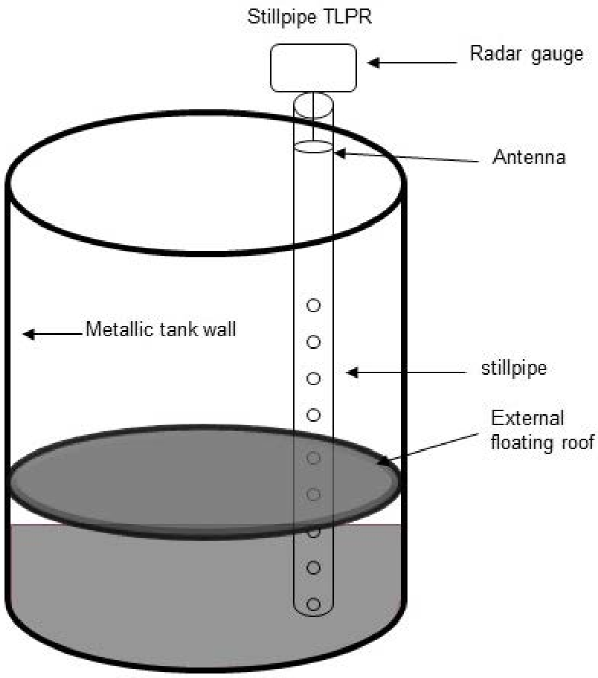


Figure 2: Stillpipe TLPR installed on external floating roof tank to measure the level inside the tank

According to ETSI TS 103 361 [10] where the test signals and test procedures are defined in clauses 8 and 9, respectively, the frequencies of the three highest interferer signals, for example, in ETSI TS 103 361 [10] are defined as the BFWA and Fixed services centred at 10,225 GHz, 10,55 GHz and 10,575 GHz. The power@device of the application-specific interferers is calculated by equation (2) in clause 7.3 of ETSI TS 103 361 [10] which is also applicable to stillpipe TLPR as EUT, i.e.:

Power@EUT [dBm] = max. e.i.r.p. [dBm] - Total attenuation [dB] (3)

And the amplitude of the highest interferer signal is -88 dBm for all three frequencies as defined in table 11 of ETSI TS 103 361 [10] for TLPR.

For stillpipe TLPR installation, the additional NLOS is the same as for TLPR service group 3 in table 10 of ETSI TS 103 361 [10]. The highest interferer level at the stillpipe TLPR receiver (i.e. power@device) is therefore -88 dBm (worst case), this is because emission and reception from and to stillpipe are not reciprocal for electromagnetic field conversion in waveguide to and from free space. In clause 8.3 emission of stillpipe is regarded as part of antenna radiation of leakage through perforations, while in clause 9 the receiver interferer signal handling, stillpipe acts as electronic fence to shield incoming signal, only matched wavelength signal with proper phase and amplitude could be converted to the confined electromagnetic field inside the pipe. Therefore the attenuation of NLOS is at least 40 dB.

The test signals at aforementioned three frequencies 10,225 GHz, 10,55 GHz and 10,575 GHz. are selected as defined in clause 8 of ETSI TS 103 361 [10].

The determined interferer frequencies and power levels shall be stated in the "application form for testing" (see annex E).

10.1.3 Real scenario

Unlike TLPR level gauges, stillpipe TLPR level gauges generate optimal electromagnetic field in such a way that the stillpipe can act as a microwave waveguide allowing radar waves to propagate inside the stillpipe with little loss over distance.

The only loss in the stillpipe is the power loss on an interface between air and a product material stored in a tank, which can be expressed by reflection coefficient of the transition from air to the surface material with relative permittivity (dielectric constant) ε_r, i.e.:

$$Interface\ loss = 20\log\left(\frac{\sqrt{\varepsilon_r}-1}{\sqrt{\varepsilon_r}+1}\right) \quad (4)$$

The real measurement scenario against a smooth flat surface consisting of a material with relative permittivity ε_r at the maximum measurement distance R_{max} under interference conditions may not be a feasible test setup in practice, as stillpipe radar sensors on the market are able to measure distances of tens of meters. Therefore, one of the three methods described below as the equivalent or the alternative scenarios can be used for setup of receiver conformance test. The equivalent and alternative scenarios shall accurately reflect the conditions of the real scenario either in a radiated measurement setup at a shorter distance or in a conducted setup.

10.1.4 Equivalent scenario

10.1.4.0 General

The aim of the equivalent scenario is to facilitate testing and to enable the possibility to carry out the measurements in the limited space at a shorter measurement distance R (R < R_{max}).

10.1.4.1 Radiated test setup for the equivalent scenario

The general test environments where the radiated measurements shall be conducted is described in annex A.

Figure 5 shows a possible radiated test setup for the equivalent scenario.

It should be noted that three interferer signals defined in clause 10.1.2 are separately generated by microwave signal generator. A test antenna with gain G_t is placed at a certain distance R from the stillpipe TLPR antenna. The interferer signal level should be equal to the levels defined in clause 10.1.2 at the EUT (stillpipe TLPR). The free space loss needs to be considered at the microwave generator and test antenna side to ensure the interferer signal level has correct value at EUT.

The test stillpipe should contain perforations on its wall and inserted with absorbing material on the bottom and a dielectric material plate with a relative permittivity ε_r that represents the worse case scenario which the stillpipe TLPR can deal with reliably. The test stillpipe shall be provided as defined in annex C.

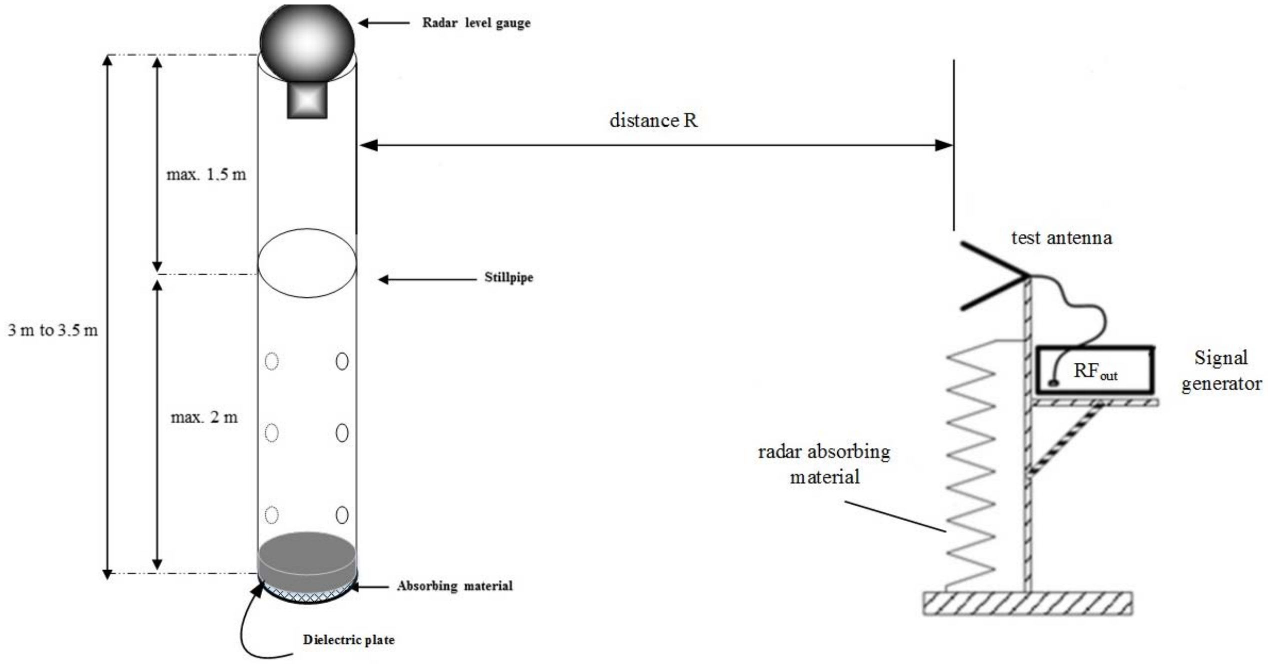


Figure 3: Radiated test setup for the equivalent scenario

10.1.4.2 Conducted test setup for the equivalent scenario

Figure 4 shows a possible conducted test setup for the equivalent scenario using coaxial components. The interferer signals are generated by a microwave signal generator which is connected to the stillpipe TLPR by means of a coaxial RF-cable, a directional coupler and an optional coaxial attenuator.

It is recommended to use different cable lengths, so that the stillpipe TLPR can separate between the desired echo from the short circuited line (see figure 4) and the unwanted reflection from the RF output stage of the microwave signal generator. The stillpipe TLPR sensor has then to be adjusted to measure the distance to the shorted coaxial cable.

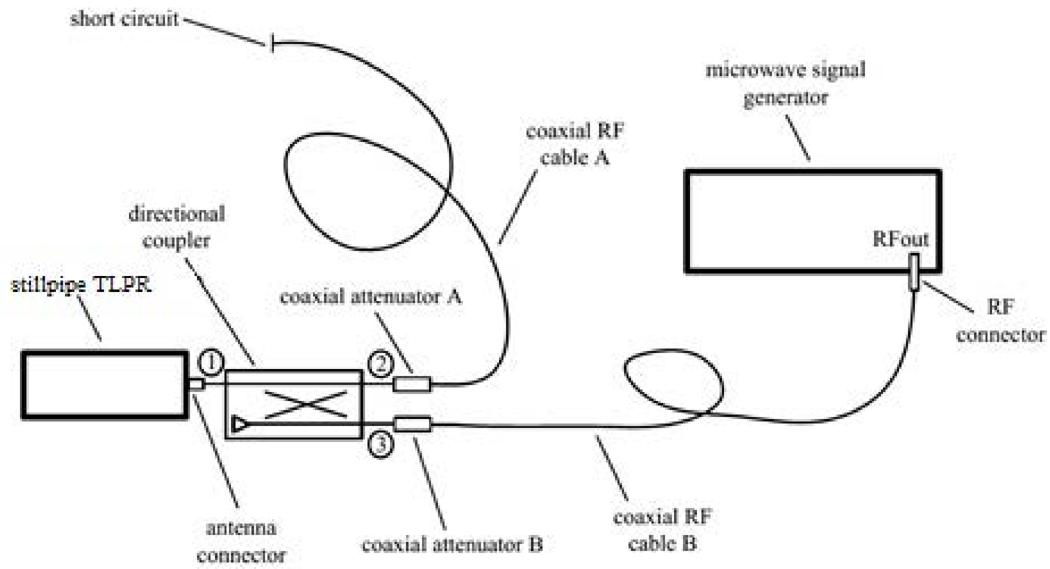


Figure 4: Conducted test setup for the equivalent scenario using coaxial components

Calculation of the required echo attenuation:

The power level of the echo signal $P_{r\_equivalent}^{dBm}$ at the stillpipe TLPR receiver during the measurement against the short circuit can be calculated according to equation (5):

$$P_{r\_equivalent}^{dBm} = P_t^{dBm} - 2\left(a_{coupler(1-2)}^{dB} + a_{cable\_A}^{dB} + a_{attn\_A}^{dB}\right) \quad (5)$$

$P_{r\_equivalent}^{dBm}$:	received echo power in the equivalent measurement scenario in dBm
P_t^{dBm} :	maximum value of transmitted peak power of the stillpipe TLPR in dBm
$a_{coupler(1-2)}^{dB}$:	coupling loss of the directional coupler between ports 1 and 2 in dB
$a_{cable\_A}^{dB}$:	cable loss of coaxial RF-cable A in dB
$a_{attn\_A}^{dB}$:	attenuation of the coaxial attenuator A in dB

The three different loss contributions are assumed to be inserted in positive dB-values in the equation above.

With the given echo power level $P_{r\_real}^{dBm}$ from the surface in the real scenario (refer to clause 10.1.3) where only the interface loss shall be considered in stillpipe, one can calculate the required attenuation of the coaxial attenuator A by setting $P_{r\_real}^{dBm} = P_{r\_equivalent}^{dBm}$ and solving the resulting equation for the additional attenuation $a_{attn\_A}^{dB}$. The interface loss defined in equation (4) should be equal to the sum of the losses of RF cable A and coaxial attenuator A as shown in figure 4.

For all choices of the attenuations in the signal path from the stillpipe TLPR to the short circuit, the following condition shall be met during the test:

$$P_{r\_real}^{dBm} = (P_t^{dBm} + Interface\ loss) \geq P_{r\_equivalent}^{dBm} \quad (6)$$

Calculation of the transmitted interferer power:

The interferer power level $P_{r\_interferer}^{dBm}$ which shall be applied to the receiver of the stillpipe TLPR device is defined in clause 10.1.2 of the present document.

The transmitted power level of the interfering signal $P_{t\_interferer}^{dBm}$ at the RF-connector of the signal generator provides the interferer signal power level $P_{r\_interferer}^{dBm}$ at the stillpipe TLPR receiver by using equation (7):

$$P_{t_{interferer}}^{dBm} = P_{r\_interferer}^{dBm} + a_{coupler(1-3)}^{dB} + a_{cable_B}^{dB} + a_{attn\_B}^{dB} \quad (7)$$

$P_{r\_interferer}^{dBm}$:	received interferer power at the stillpipe TLPR receiver in dBm
$P_{t_{interferer}}^{dBm}$:	transmitted interferer power (generated by the signal generator) in dBm
$a_{coupler(1-3)}^{dB}$:	coupling loss of the directional coupler between ports 1 and 3 in dB
$a_{cable\_B}^{dB}$:	cable loss of coaxial RF-cable B in dB
$a_{attn\_B}^{dB}$:	attenuation of the coaxial attenuator B in dB

The different losses are assumed to be inserted in positive dB-values in the equation (6).

10.1.4.3 Test procedure for the equivalent scenario

The test for interferer signal handling using the equivalent scenario shall be conducted as follows:

- The measurement setup for the equivalent scenario is arranged according to the figure 3 (radiated) and figure 4 (conducted), respectively.
- The interferer frequencies $f_{interferer}$ and power levels $P_{r\_interferer}$ are defined in clause 10.1.2, the transmitted interferer power levels (microwave signal generator output power) $P_{t\_interferer}$ can be determined according to individual test setup scenario described in clause 10.1.4.1 and clause 10.1.4.2.
- With the specifications of ε_r for the stillpipe TLPR under test in the "application form for testing", the conducted test setup determines the received echo power $P_{r\_real}^{dBm}$ according to clause 10.1.4.2. Then the required attenuation in the signal path of the stillpipe TLPR can be calculated following the instructions in clause 10.1.4.2. The resulting received echo power $P_{r\_equivalent}$ shall be equal or less than the received echo power P_{r_real} in the real scenario. For the radiated test setup, the relative permittivity of the material inserted in the stillpipe should be equal to that in the application form. The transmitted interferer signal power level shall be determined in a way that the received power level of the interfere signal at EUT or the stillpipe is not less than the interferer signal level defined in clause 10.1.2. The power level of interferer signal generated by the signal generator shall be tuned with taking into account the test antenna, cable and spread loss to ensure the correct power level of interferer signal arriving at EUT or stillpipe. The test will be repeated for each of three interferer frequencies defined at clause 10.1.2.
- The distance measurement is carried out against the radar target in the radiated setup (see figure 3) or against the shorted coaxial cable in the conducted setup (see figure 4) with/without the presence of an interferer signal.
- Compare the two measured distance values with and without presence of an interferer signal defined at clause 10.1.2, the test is passed if the measured distance variation between the two measurements stays within the maximum measurement value variation Δd as defined in clause 9.3. The test shall be conducted over at least a time period of 120 seconds or 40 times the step response time of the stillpipe TLPR sensor, whichever is longer.
- During this test the stillpipe TLPR sensor shall be configured for the fastest possible step response time. Therefore, all averaging functions and echo holding techniques shall be deactivated. If a complete deactivation of these functions is not possible, they shall be set to a state which ensures the fastest possible step response time. The configuration of the device under test in this case shall be noted in the test report.
- If the step response of the stillpipe TLPR sensor is not known, it can be estimated by introducing a sudden change of the target distance in a radiated setup or to a short circuit in a conducted setup), respectively. The step response time is the time span until the new distance value reaches 90 % of the final value.

- Attention has to be paid that the correct echo is tracked by the stillpipe TLPR device during the test. This shall be verified by switching off the interferer signal. In this case the distance value shall also stay inside the maximum measurement variation Δd.
- The test shall be repeated for all determined interferers (refer to clauses 7.7 and 9.3 of ETSI TS 103 361 [10] and clause 10.1.2 of the present document).

10.1.5 Alternative scenario

10.1.5.0 General

The aim of the alternative scenario (in comparison to the equivalent scenario in clause 10.1.4) is to further facilitate testing without the need for a simultaneous distance measurement. The interfering signal is directly coupled into the receiver and the response of the noise floor of the stillpipe TLPR device is monitored (figure 5).

For applying this alternative scenario it is mandatory that the stillpipe TLPR provides the possibility to access and monitor its noise level for example in an "echo curve" or reflection diagram. If the stillpipe TLPR under test does not provide this feature the equivalent scenario in clause 10.1.4 has to be used for testing.

It is known that an interferer signal may cause the increase of the noise floor in the receiver if the receiver is susceptible to such an interferer. Thus, increased noise floor will reduce receiver performance. If the noise floor of the receiver remains at a level of variation less than or equal to 3 dB that is approximate to measurement uncertainties as defined in clause 7, a measurement variation of Δd ≤ ±50 mm can be assured.

The manufacturer shall supply the relation between the measurement value variation Δd ≤ ±50 mm and the maximum noise floor for the individual stillpipe TLPR under test. This can preferably be achieved by providing recorded measurement data. The maximum noise floor shall be noted in the "application form for testing" (refer to annex E).

10.1.5.1 Conducted test setup for the alternative scenario

Figures 7 and 8 show a possible conducted test setup for the alternative scenario. It is noted that they describe only noise floor measurements with and without interferer signal injection. If the noise floor, after injection of an interferer signal, is increased less than or equal to 3 dB, then the result of the alternative test scenario can be used to declare the conformance. Otherwise it is not the suitable test method and this alternative method shall be replaced by one of the equivalent test methods defined in clause 10.1.4.

The interferer signal which has to be provided to the stillpipe TLPR receiver is generated by the signal generator and is directly fed to the stillpipe TLPR under test via a suitable RF cable or hollow waveguide.

The exact interferer power level $P_{r\_interferer}^{dBm}$ which shall be applied to the receiver of the stillpipe TLPR device is defined in clause 10.1.2 of the present document.

The required power level of the interfering signal at the stillpipe TLPR receiver $P_{r\_interferer}^{dBm}$ can be adjusted at the signal generator by taking into account attenuations between the RF connector and the stillpipe TLPR feedthrough connector. An external attenuator may be used during the test as illustrated in the measurement setup in figures 5 and 6.

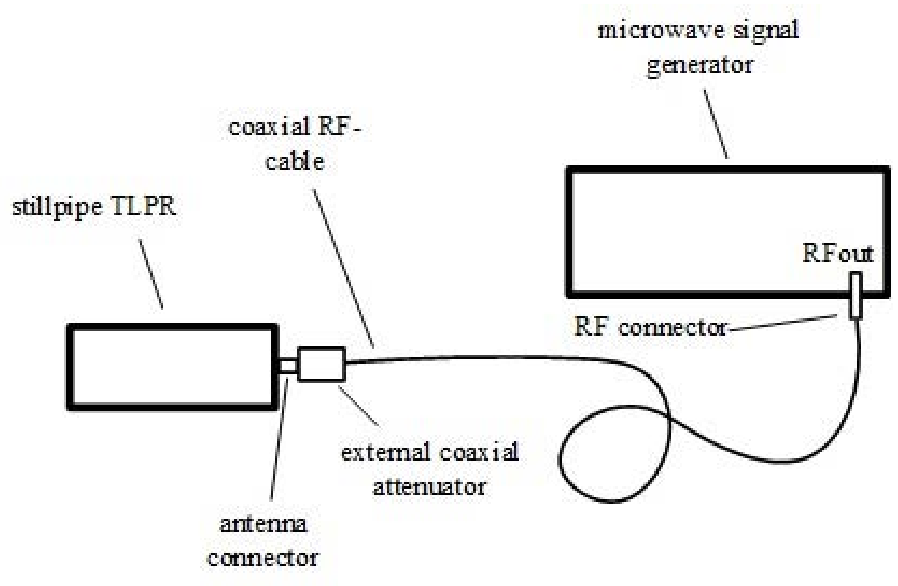


Figure 5: Conducted test setup for Rx noise floor measurement with injection of interference signal

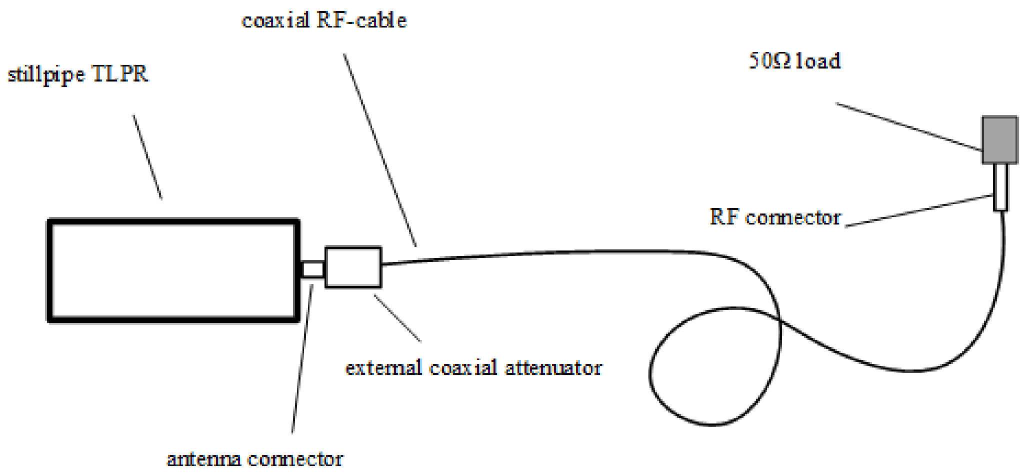


Figure 6: Conducted test setup for Rx noise floor measurement without injection of interference signal

10.1.5.2 Test procedure for the alternative scenario

The test for interferer signal handling using the alternative scenario shall be conducted as follows:

- The interferer frequencies $f_{interferer}$ and power levels $P_{r\_interferer}$ are determined according to clause 10.1.2 the transmitted interferer power levels (signal generator output power) $P_{t\_interferer}$ can be determined by means of the methods provided in clause 10.1.5.1.
- The alternative measurement setup is arranged according to clause 10.1.5.1 (refer to figure 5 and figure 6).
- The setup is first arranged according to figure 5. The interfering signal is turned on and the noise level of the stillpipe TLPR under test is monitored for example in an "echo curve" or reflection diagram. Note down or record the measured noise floor value A as receiver noise with injection of the interfere signal.
- Disconnect the cable from the microwave signal generator as the interferer source. Re-connect the cable with 50-ohm load according to figure 6.

- Measure the noise floor again and note down or record the measured value B as receiver noise without injection of an interferer signal.
- The manufacturer shall supply the relation between the measurement value variation $\Delta d \leq \pm 50$ mm and the maximum noise floor for the individual stillpipe TLPR under test. The maximum permissible noise for the individual stillpipe TLPR can be extracted from the enclosed "application form for testing" in annex E.
- Compare the two measured values, the test passes, if the difference between noise floor value A and noise floor value B is less than or equal to 3 dB. Thereby a measurement variation of $\Delta d \leq \pm 50$ mm can be assured over time. The test shall be conducted over at least a time period of 120 seconds or 40 times the step response time of the stillpipe TLPR sensor, whichever is longer.
- During this test the stillpipe TLPR sensor shall be configured for the fastest possible step response time. Therefore all averaging functions and echo holding techniques shall be deactivated. If a complete deactivation of these functions is not possible, they shall be set to a state which ensures the fastest possible step response time. The configuration of the device under test in this case shall be noted in the test report.
- If the step response of the stillpipe TLPR sensor is not known, it can be estimated by introducing a sudden change of the target distance in a radiated setup or to a short circuit in a conducted setup), respectively. The step response time is the time span until the new distance value reaches 90 % of the final value.
- The test shall be repeated for all determined interferers (refer to clauses 7.7 and 9.3 of ETSI TS 103 361 [10]) and clause 10.1.2 of the present document.

Annex A (normative): Radiated measurements

A.0 General

This annex has been drafted so it covers test sites and methods to be used with integral antenna equipment or dedicated antenna for equipment having an antenna connector.

A.1 Test sites and general arrangements for measurements involving the use of radiated fields

A.1.0 Anechoic Chamber

This annex introduces three most commonly available test sites, an anechoic chamber, an anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in the relevant parts of ETSI TR 102 273 [8] or equivalent.

NOTE: To ensure reproducibility and tractability of radiated measurements only these test sites should be used in measurements in accordance with the present document.

A.1.1 Anechoic Chamber

An anechoic chamber is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The chamber usually contains an antenna support at one end and a turntable at the other. A typical anechoic chamber is shown in figure A.1.

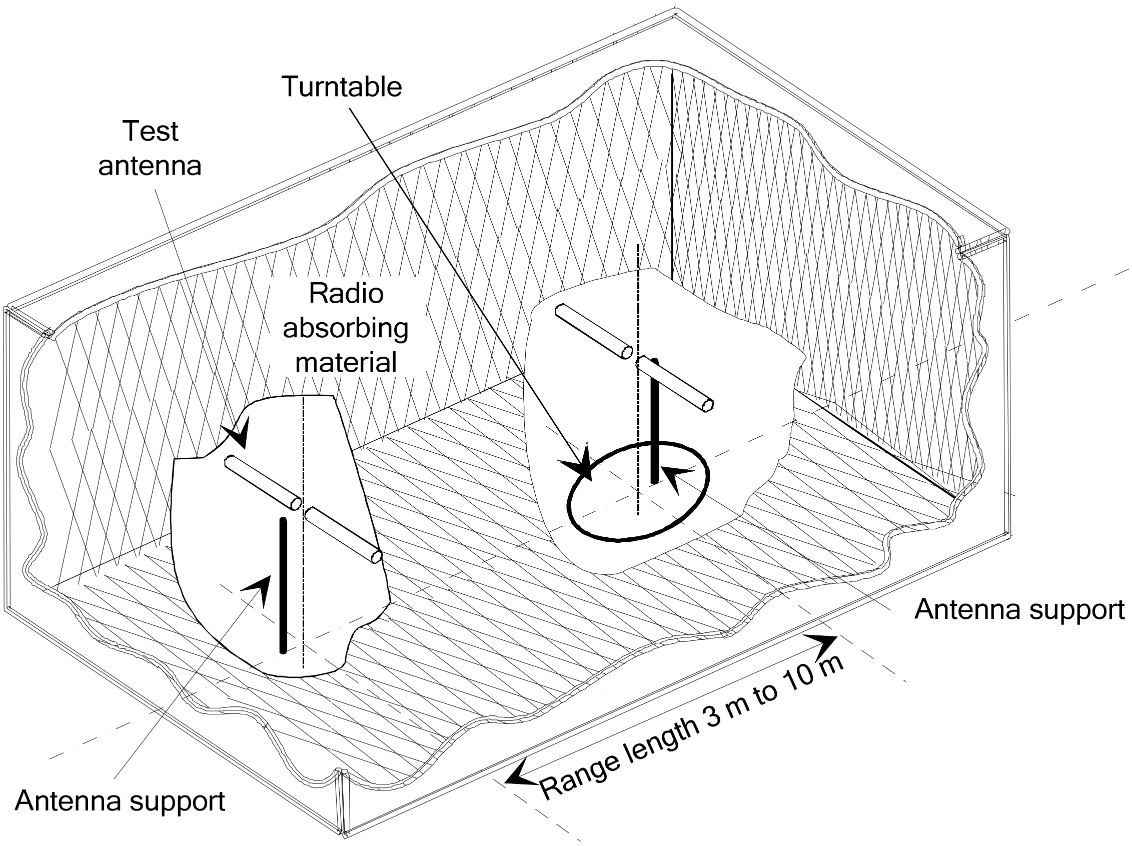


Figure A.1: A typical Anechoic Chamber

The chamber shielding and radio absorbing material work together to provide a controlled environment for testing purposes. This type of test chamber attempts to simulate free space conditions.

The shielding provides a test space, with reduced levels of interference from ambient signals and other outside effects, whilst the radio absorbing material minimizes unwanted reflections from the walls and ceiling which can influence the measurements. In practice it is relatively easy for shielding to provide high levels (80 dB to 140 dB) of ambient interference rejection, normally making ambient interference negligible.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a suitable height (e.g. 1 m) above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1 + d_2)^2/\lambda$ (m), whichever is greater (see clause A.2.4). For further information on measurements at shorter distances see annex F. The distance used in actual measurements shall be recorded with the test results.

The anechoic chamber generally has several advantages over other test facilities. There is minimal ambient interference, minimal floor, ceiling and wall reflections and it is independent of the weather. It does however have some disadvantages which include limited measuring distance and limited lower frequency usage due to the size of the pyramidal absorbers. To improve low frequency performance, a combination structure of ferrite tiles and urethane foam absorbers is commonly used.

All types of emission, sensitivity and immunity testing can be carried out within an anechoic chamber without limitation.

A.1.2 Anechoic Chamber with a conductive ground plane

An anechoic chamber with a conductive ground plane is an enclosure, usually shielded, whose internal walls and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The floor, which is metallic, is not covered and forms the ground plane. The chamber usually contains an antenna mast at one end and a turntable at the other. A typical anechoic chamber with a conductive ground plane is shown in figure A.2.

This type of test chamber attempts to simulate an ideal Open Area Test Site whose primary characteristic is a perfectly conducting ground plane of infinite extent.

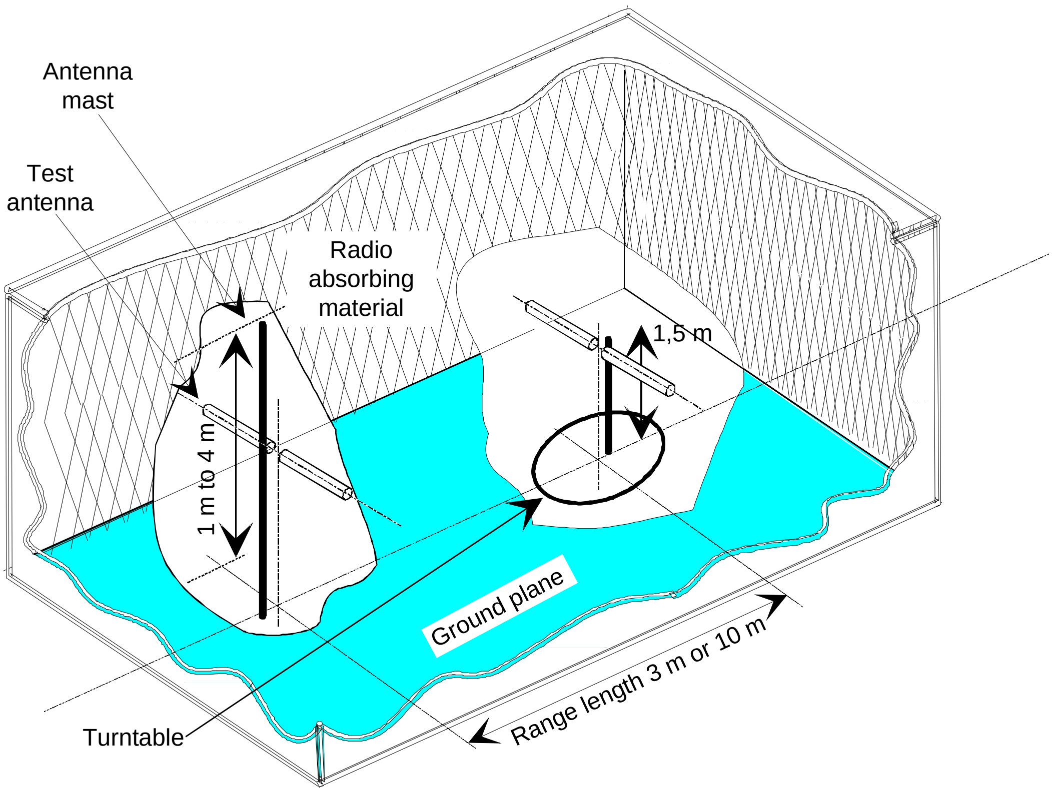


Figure A.2: A typical Anechoic Chamber with a conductive ground plane

In this facility the ground plane creates the wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals from both the direct and reflected transmission paths. This creates a unique received signal level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

The antenna mast provides a variable height facility (from 1 m to 4 m) so that the position of the test antenna can be optimized for maximum coupled signal between antennas or between an EUT and the test antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1 + d_2)^2/\lambda$ (m), whichever is greater (see clause A.2.4.). For further information on measurements at shorter distances see annex F. The distance used in actual measurements shall be recorded with the test results.

Emission testing involves firstly "peaking" the field strength from the EUT by raising and lowering the receiving antenna on the mast (to obtain the maximum constructive interference of the direct and reflected signals from the EUT) and then rotating the turntable for a "peak" in the azimuth plane. At this height of the test antenna on the mast, the amplitude of the received signal is noted. Secondly the EUT is replaced by a substitution antenna (positioned at the EUT's phase or volume centre) which is connected to a signal generator. The signal is again "peaked" and the signal generator output adjusted until the level, noted in stage one, is again measured on the receiving device.

Receiver sensitivity tests over a ground plane also involve "peaking" the field strength by raising and lowering the test antenna on the mast to obtain the maximum constructive interference of the direct and reflected signals, this time using a measuring antenna which has been positioned where the phase or volume centre of the EUT will be during testing. A transform factor is derived. The test antenna remains at the same height for stage two, during which the measuring antenna is replaced by the EUT. The amplitude of the transmitted signal is reduced to determine the field strength level at which a specified response is obtained from the EUT.

A.1.3 Open Area Test Site (OATS)

An Open Area Test Site comprises a turntable at one end and an antenna mast of variable height at the other end above a ground plane which, in the ideal case, is perfectly conducting and of infinite extent. In practice, whilst good conductivity can be achieved, the ground plane size has to be limited. A typical Open Area Test Site is shown in figure A.3.

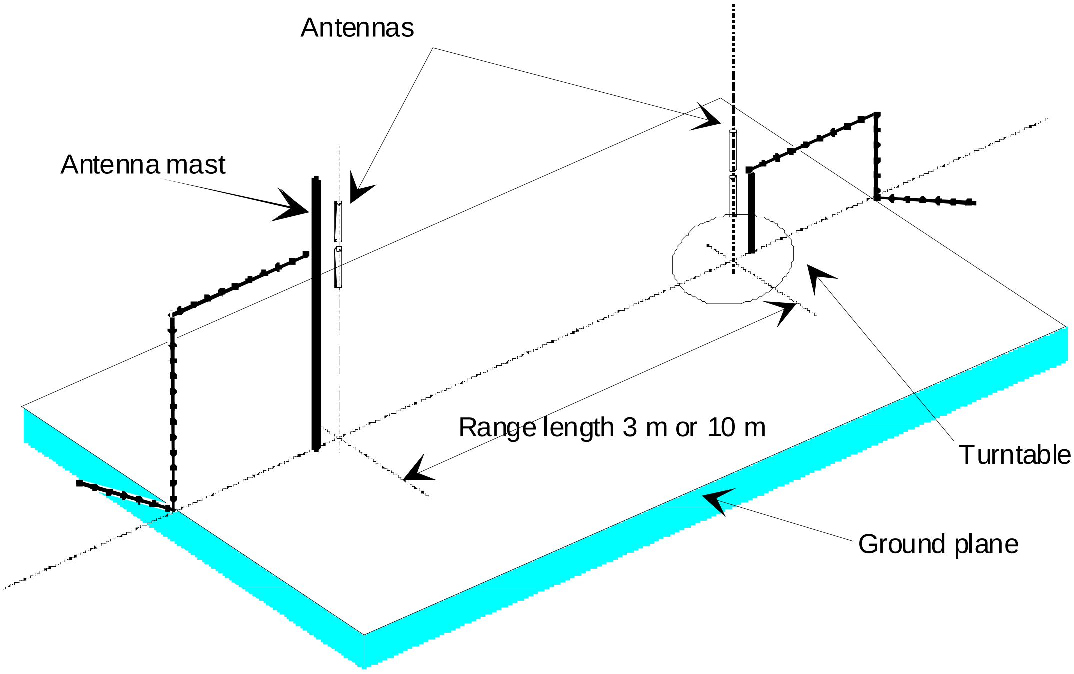


Figure A.3: A typical Open Area Test Site

The ground plane creates a wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals received from the direct and reflected transmission paths. The phasing of these two signals creates a unique received level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

Site qualification concerning antenna positions, turntable, measurement distance and other arrangements are same as for anechoic chamber with a ground plane. In radiated measurements an OATS is also used by the same way as anechoic chamber with a ground plane.

Typical measuring arrangement common for ground plane test sites is presented in the figure A.4.

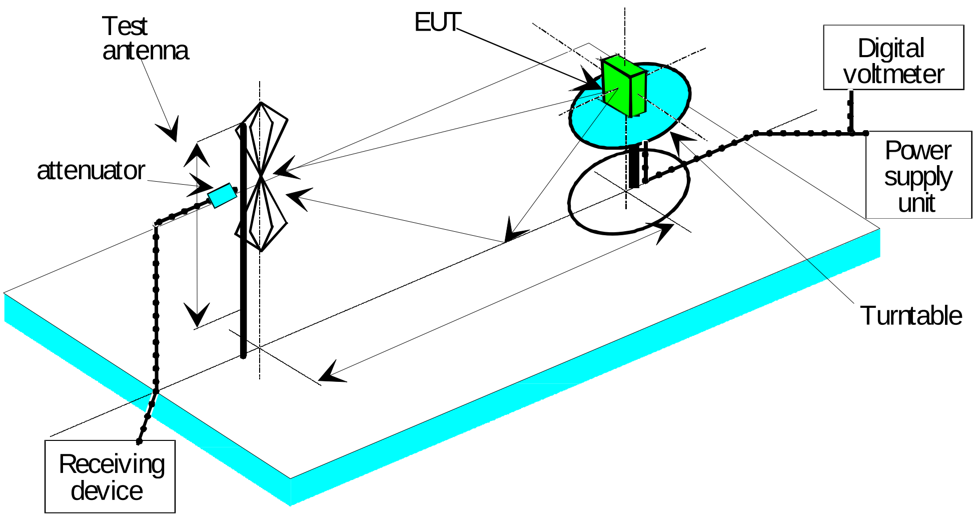


Figure A.4: Measuring arrangement on ground plane test site (OATS set-up for unwanted emission testing)

A.1.4 Test antenna

A test antenna is always used in radiated test methods. In emission tests the test antenna is used to detect the field from the EUT in one stage of the measurement and from the substitution antenna in the other stage. When the test site is used for the measurement of receiver characteristics (i.e. sensitivity and various immunity parameters) the antenna is used as the transmitting device.

The test antenna should be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization which, on ground plane sites (i.e. anechoic chambers with ground planes and Open Area Test Sites), should additionally allow the height of its centre above the ground to be varied over the specified range (usually 1 m to 4 m).

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [2]) are generally recommended. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For unwanted emission testing, however, a combination of bicones and log periodic dipole array antennas (commonly termed "log periodics") could be used to cover the entire 30 MHz to 1 000 MHz band. Above 1 000 MHz, waveguide horns are recommended although, again, log periodics could be used.

NOTE: The gain of a horn antenna is generally expressed relative to an isotropic radiator.

A.1.5 Substitution antenna

The substitution antenna is used to replace the EUT for tests in which a transmitting parameter is being measured. For measurements in the frequency band 30 MHz to 1 000 MHz, the substitution antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [2]). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For measurements above 1 000 MHz, a waveguide horn is recommended. The centre of this antenna should coincide with either the phase centre or volume centre.

A.1.6 Measuring antenna

The measuring antenna is used in tests on an EUT in which a receiving parameter (i.e. sensitivity and various immunity tests) is being measured. Its purpose is to enable a measurement of the electric field strength in the vicinity of the EUT. For measurements in the frequency band 30 MHz to 1 000 MHz, the measuring antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [2]. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the EUT.

A.2 Guidance on the use of radiation test sites

A.2.0 General

This clause details procedures, test equipment arrangements and verification that should be carried out before any of the radiated test are undertaken. These schemes are common to all types of test sites described in annex A.

A.2.1 Verification of the test site

No test should be carried out on a test site, which does not possess a valid certificate of verification. The verification procedures for the different types of test sites described in annex A (i.e. anechoic chamber, anechoic chamber with a ground plane and Open Area Test Site) are given in the relevant parts of ETSI TR 102 273 [8] or equivalent.

A.2.2 Preparation of the EUT

The manufacturer should supply information about the EUT covering the operating frequency, polarization, supply voltage(s) and the reference face. Additional information, specific to the type of EUT should include, where relevant, carrier power, channel separation, whether different operating modes are available (e.g. high and low power modes) and if operation is continuous or is subject to a maximum test duty cycle (e.g. 1 min on, 4 min off).

Where necessary, a mounting bracket of minimal size should be available for mounting the EUT on the turntable. This bracket should be made from low conductivity, low relative dielectric constant (i.e. less than 1,5) material(s) such as expanded polystyrene, balsa wood, etc.

A.2.3 Power supplies to the EUT

All tests should be performed using power supplies wherever possible, including tests on EUT designed for battery-only use. In all cases, power leads should be connected to the EUT's supply terminals (and monitored with a digital voltmeter) but the battery should remain present, electrically isolated from the rest of the equipment, possibly by putting tape over its contacts.

The presence of these power cables can, however, affect the measured performance of the EUT. For this reason, they should be made to be "transparent" as far as the testing is concerned. This can be achieved by routing them away from the EUT and down to either the screen, ground plane or facility wall (as appropriate) by the shortest possible paths. Precautions should be taken to minimize pick-up on these leads (e.g. the leads could be twisted together, loaded with ferrite beads at 0,15 m spacing or otherwise loaded).

A.2.4 Range length

The range length for all these types of test facility should be adequate to allow for testing in the far-field of the EUT i.e. it should be equal to or exceed:

$$\frac{2(d_1 + d_2)^2}{\lambda} \quad \text{(A.1)}$$

where:

- d_1 is the largest dimension of the EUT/dipole after substitution (m);
- d_2 is the largest dimension of the test antenna (m);
- λ is the test frequency wavelength (m).

It should be noted that in the substitution part of this measurement, where both test and substitution antennas are half wavelength dipoles, this minimum range length for far-field testing would be:

$$2\lambda$$

It should be noted in the test report when either of these conditions is not met so that the additional measurement uncertainty can be incorporated into the results.

For further information on measurements at shorter distances see annex C.

NOTE 1: For the fully anechoic chamber, no part of the volume of the EUT should, at any angle of rotation of the turntable, fall outside the "quiet zone" of the chamber at the nominal frequency of the test.

NOTE 2: The "quiet zone" is a volume within the anechoic chamber (without a ground plane) in which a specified performance has either been proven by test, or is guaranteed by the designer/manufacture. The specified performance is usually the reflectivity of the absorbing panels or a directly related parameter (e.g. signal uniformity in amplitude and phase). It should be noted however that the defining levels of the quiet zone tend to vary.

NOTE 3: For the anechoic chamber with a ground plane, a full height scanning capability, i.e. 1 m to 4 m, should be available for which no part of the test antenna should come within 1 m of the absorbing panels. For both types of Anechoic Chamber, the reflectivity of the absorbing panels should not be worse than -5 dB.

NOTE 4: For both the anechoic chamber with a ground plane and the Open Area Test Site, no part of any antenna should come within 0,25 m of the ground plane at any time throughout the tests. Where any of these conditions cannot be met, measurements should not be carried out.

A.2.5 Site preparation

The cables for both ends of the test site should be routed horizontally away from the testing area for a minimum of 2 m (unless, in the case either type of anechoic chamber, a back wall is reached) and then allowed to drop vertically and out through either the ground plane or screen (as appropriate) to the test equipment. Precautions should be taken to minimize pick up on these leads (e.g. dressing with ferrite beads, or other loading). The cables, their routing and dressing should be identical to the verification set-up.

NOTE: For ground reflection test sites (i.e. anechoic chambers with ground planes and Open Area Test Sites) which incorporate a cable drum with the antenna mast, the 2 m requirement may be impossible to comply with.

Calibration data for all items of test equipment should be available and valid. For test, substitution and measuring antennas, the data should include gain relative to an isotropic radiator (or antenna factor) for the frequency of test. Also, the VSWR of the substitution and measuring antennas should be known.

The calibration data on all cables and attenuators should include insertion loss and VSWR throughout the entire frequency range of the tests. All VSWR and insertion loss figures should be recorded in the log book results sheet for the specific test.

Where correction factors/tables are required, these should be immediately available.

For all items of test equipment, the maximum errors they exhibit should be known along with the distribution of the error e.g.:

- cable loss: ±0,5 dB with a rectangular distribution;
- measuring receiver: 1,0 dB (standard deviation) signal level accuracy with a Gaussian error distribution.

At the start of measurements, system checks should be made on the items of test equipment used on the test site.

A.3 Coupling of signals

A.3.1 General

The presence of leads in the radiated field may cause a disturbance of that field and lead to additional measurement uncertainty. These disturbances can be minimized by using suitable coupling methods, offering signal isolation and minimum field disturbance (e.g. optical and acoustic coupling).

Annex B (normative): Installation requirements for stillpipe TLPR

This annex provides the information for radar level gauges manufacturers and installers to design the equipment and the installation in the tank in such a way, that the requirements as stated in Commission Decision 2007/131/EC [i.8] on UWB devices are fulfilled.

The following installation requirements shall be fulfilled:

a) Radar level gauging applications together with the dedicated stillpipe are required to be installed at a permanent fixed position in a floating roof tank.

b) Flanges and attachments of the radar head on the stillpipe shall provide the necessary microwave sealing by design.

c) Installation and maintenance of the radar level gauging equipment shall be performed by professionally trained individuals only.

The manufacturer is required to inform the users and installers of radar level gauging equipment about the installation requirements and, if applicable, the additional special mounting instructions (e.g. by putting it in the product manual).

Annex C (normative): Requirements on a test stillpipe

C.1 General

The following requirements shall apply for a test pipe:

- The test stillpipe shall have the same proportions as an original size stillpipe according to ISO 4266-1 [4] or API Chapter 3.1B [5] while the maximum size of the test pipe shall be 3 m to 3,5 m.
- In its original application the stillpipe's perforations are always absent 0,5 m to 1 m below the top of the tank shell. Thus the upper part (screening/shielding part) of the test stillpipe where the stillpipe TLPR is installed shall either have the original size and proportions or a maximum of 1,5 m.
- The lower part (leaking part) of the test stillpipe shall have a length of 2 m and shall be perforated as worst case scenario according to the original perforations as per ISO 4266-1 [4] and/or API Chapter 3.1B [5].
- Although the test stillpipe shall be made of metal with its original proportions the stillpipe together with the stillpipe TLPR shall have a weight that is convenient enough for the test laboratory to conduct the tests.

The specified test pipe is used as a worst-case scenario for measuring the total emission outside a floating roof tank.

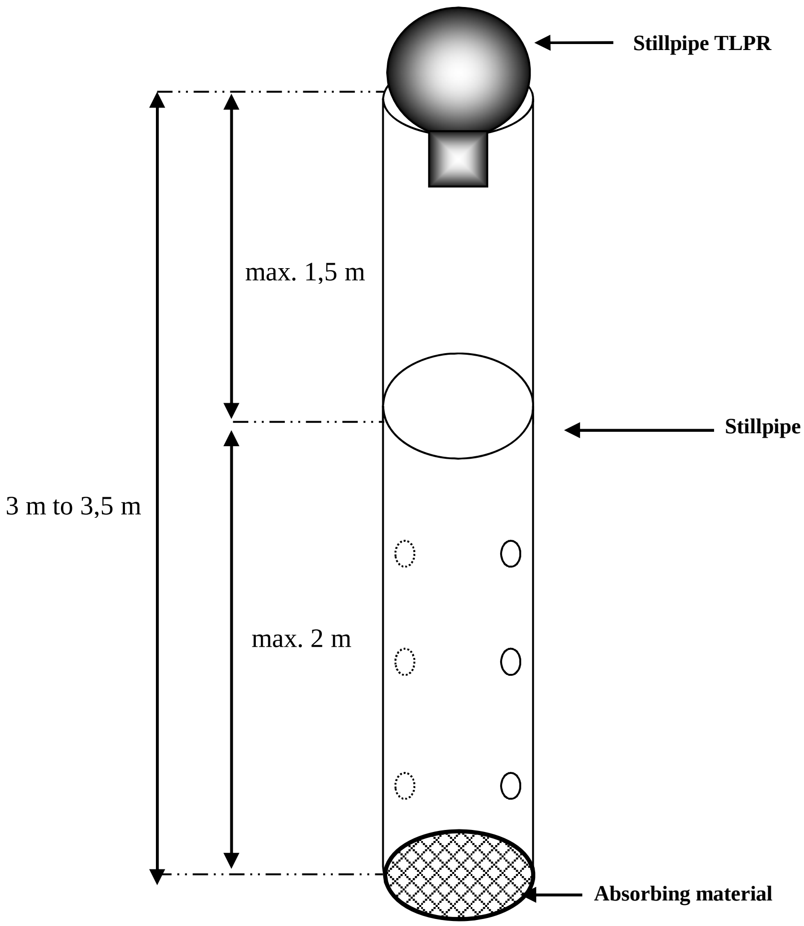
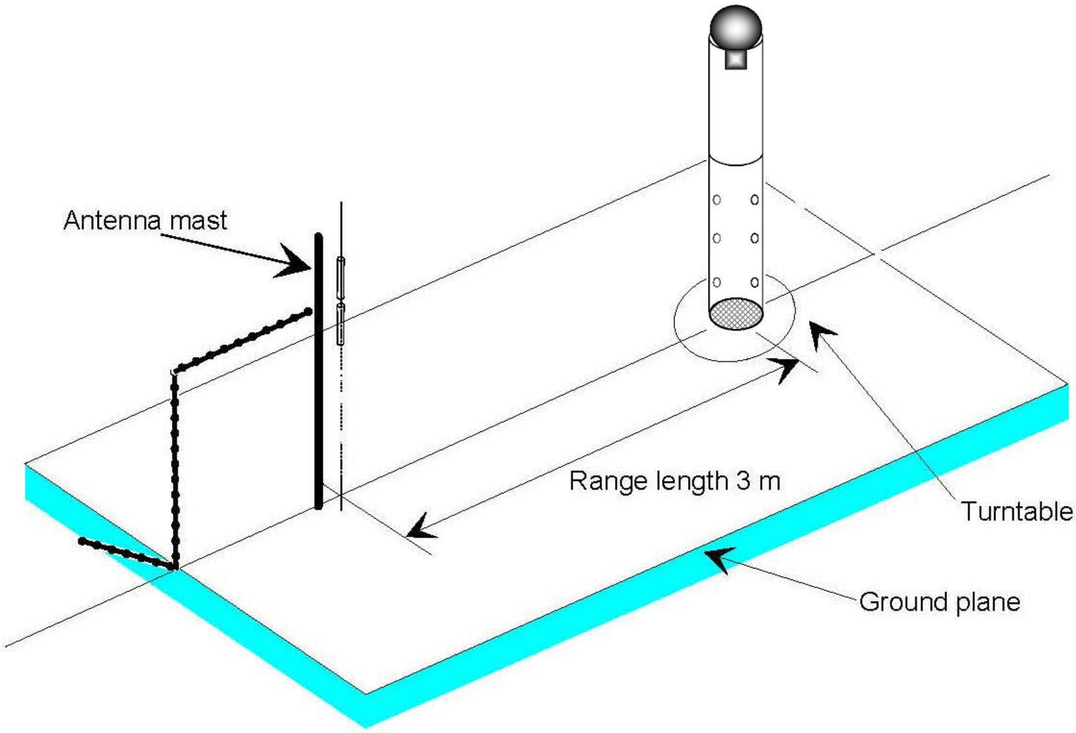


Figure C.1: Test set-up for measuring the operating frequency range

C.2 Measurement setup



NOTE: Should the sensitivity not be sufficient, the measurement distance can be reduced to 1 m.

Figure C.2: Test set-up example for measurements with a test stillpipe in an OATS

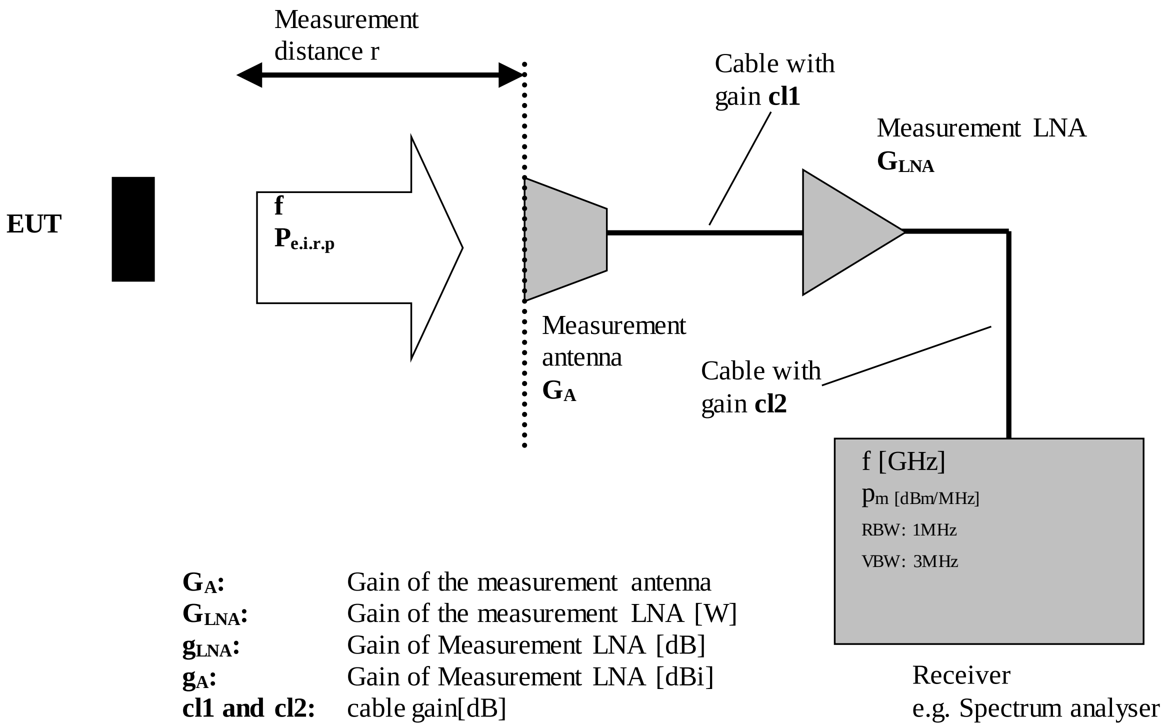


Figure C.3: Test set-up for emission measurements

Conversion:

$$g_{LNA} = 20\log(G_{LNA})$$

$$g_A = 10\log(G_A)$$

$$cl_x = 10^{\left(\frac{Cl_x}{20}\right)}$$

Equation (Values [dB]):

$$p_{e.i.r.p} = p_m - g_A - cl1 - cl2 - g_{LNA} + 20 \cdot \log\left(\frac{4\pi r}{\lambda}\right) \qquad \text{[dBm/MHz]}$$

The values of the cable gain Cl1 and Cl2 are smaller than one. Consequently the logarithmic values cl1 and cl2 are negative!

A test site selected from annex A, which fulfils the requirements of the specified frequency range and undisturbed lowest specified emission levels of this measurement shall be used.

Annex D (informative): Measurement antenna and preamplifier specifications

The radiated measurements set-up in clause 8 specifies the use of the wide-band horn antenna and a wide-band, high gain preamplifier in order to measure the very low radiated power spectral density level from the EUT mounted in a stillpipe.

Table D.1 gives examples of minimum recommended data and features for the horn antenna and preamplifier to be used for the test set-up.

Table D.1: Recommended minimum performance data for preamplifier and antenna

Pre-amplifier	
Bandwidth	30 MHz to 22,5 GHz
Noise figure	< 3 dB
Output at 1dB compression	5 dBm
Gain	27 dB
Gain flatness across band	±2,5 dB
Phase response	Linear
VSWR in/out across band	2,5:1
Nominal impedance RF Connector or waveguide size	50 Ω

Antenna	
Type of Antenna	**Log. Periodic/Horn**
Bandwidth	30 MHz to 22,5 GHz
Gain	8,5 dBi
Nominal Impedance	50 Ω
VSWR across band	< 2,5:1
Connector or waveguide connection	PC 3,5 (SMA)

Measuring the complete emission spectrum, several measurement antennas will be required, each optimized over a distinct frequency range.

Table D.2: Recommended measurement antennas

Antenna type	Frequency range
λ/2 - dipole or biconical	30 MHz to 200 MHz
λ/2 - dipole or log periodic	200 MHz to 1 000 MHz
Horn	> 1 000 MHz

Annex E (informative): Application form for testing

E.1 Introduction

Notwithstanding the provisions of the copyright clause related to the text of the present document, ETSI grants that users of the present document may freely reproduce the application form proforma in this annex so that it can be used for its intended purposes and may further publish the completed application form.

The form contained in this annex may be used by the supplier to comply with the requirement contained in clause 5 to provide the necessary information about the equipment to the test laboratory prior to the testing. It contains product information as well as other information which might be required to define which configurations are to be tested, which tests are to be performed as well the test conditions.

This application form should form an integral part of the test report.

E.2 General information as required by ETSI TS 102 692, clause 10

E.2.1 Type of equipment (stand-alone, combined, plug-in radio device, etc.)

☐ Stand-alone

☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)

☐ Plug-in radio device (Equipment intended for a variety of host systems)

☐ Other ....

E.2.2 The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices

Details provided are for the: ☐ stand-alone equipment

☐ combined (or host) equipment

☐ test jig

Supply Voltage ☐ AC mains State AC voltage ……….. V

☐ DC State DC voltage ……….. V

In case of DC, indicate the type of power source

☐ Internal Power Supply

☐ External Power Supply or AC/DC adapter

☐ Battery

☐ Other: ....

E.3 Signal related information as required by ETSI TS 102 692, clause 10

E.3.1 Introduction

The following information is provided by the supplier.

E.3.2 Operational frequency range(s) of the equipment

- Operational Frequency Range 1: .... MHz to .... MHz
- Operational Frequency Range 2: .... MHz to .... MHz

NOTE: Add more lines if more Frequency Ranges are supported.

E.3.3 The type of modulation used by the equipment

☐ FMCW

☐ SFCW

E.3.4 The worst case mode for each of the following tests

NOTE: In this clause specify the operational mode and not the measured value. E.g. test mode 1 that gives the worst case for the following parameters.

- Operational Frequency Range

  ....

- Mean Power Spectral Density / Peak Power Spectral Density / Total Power / Other Emissions / Transmitter unwanted emissions

  ....

E.4 Receiver test information as required by ETSI TS 102 692, clause 9

E.4.1 Worst case mode for RX tests

Declare gauge settings:..……..

E.4.2 Performance criterion and level of performance

- performance criterion : distance value variation Δd over time.
- level of performance: ....(max limit Δd ≤ ±50 mm).

The performance criterion and the level of performance should also be stated in the user manual.

E.4.3 Receiver test setup

Specify which test setup is used under clause 10:

....

- Declaration of the parameters in the real scenario (clause 10.1.3):

  Maximum measurement distance under interference conditions R_{max}: ....m

  Surface material with relative permittivity ε_r: ....

- Declaration of the parameter in the alternative scenario (clause 10.1.5):

  Maximum permissible noise floor B=………dBm

  Relation between measurement value variation Δd and maximum permissible noise floor B, i.e.

  Δd =……. When the EUT noise floor is equal or less than B.

E.4.4 Definition of interfering signals

The list of the three worst-case interferers is chosen from ETSI TS 103 361 [10].

Frequency [MHz]	Power [dBm]	Type of signal

E.5 Information on mitigation techniques as required by ETSI TS 102 692, clause 8.4

E.5.1 Mitigation techniques

The inclusion and any necessary implementation details of any mitigation or equivalent mitigation techniques should be be declared below.

☐ Frequency domain mitigation

Specify...

☐ Shielding effects

Specify...

☐ Equivalent mitigation techniques

Specify...

☐ Others

Specify……………………..

E.6 Additional information provided by the applicant

E.6.1 About the equipment under test

☐ The equipment submitted are representative production models.

☐ If not, the equipment submitted are pre-production models?

☐ If pre-production equipment are submitted, the final production equipment will be identical in all radio related respects with the equipment tested.

☐ If not, supply full details:

....

....

☐ The equipment submitted is CE marked.

E.6.2 Additional items and/or supporting equipment provided

☐ Spare batteries (e.g. for portable equipment)

☐ Battery charging device

☐ External Power Supply or AC/DC adapter

☐ Test Jig or interface box

☐ RF test fixture (for equipment with integrated antennas)

☐	Host System	Manufacturer:	....
		Model #:	....
		Model name:	....
☐	Combined equipment	Manufacturer:	....
		Model #:	....
		Model name:	....

☐ User Manual or Technical documentation

Annex F (informative): Bibliography

- ETSI EN 303 883 (V1.1.1): "Short Range Devices (SRD) using Ultra Wide Band (UWB); Measurement Techniques".
- European Commission Decision 2013/752/EU amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2005/928/EC.
- ETSI EN 301 489-33 (V2.1.0): "ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 33: Specific conditions for Ultra-WideBand (UWB) devices; Harmonised Standard covering the essential requirements of article 3.1(b) of the Directive 2014/53/EU".
- ETSI EN 302 372 (V2.1.0): "Short Range Devices (SRD); Tank Level Probing Radar (TLPR) equipment operating in the frequency ranges 4,5 GHz to 7 GHz, 8,5 GHz to 10,6 GHz, 24,05 GHz to 27 GHz, 57 GHz to 64 GHz, 75 GHz to 85 GHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

Annex G (informative): Change History

Version	Information about changes
1.2.1	First published version covering Directive 2014/53/EU [i.3]. Major changes are: • Inclusion of Receiver Interferer Signal Handling as a new requirement. • Inclusion of test methods required for alignment with Directive 2014/53/EU [i.3].

History

Document history		
V1.1.1	June 2009	Publication
V1.2.1	August 2016	Publication